ICP Newsletter

Fall 1998

featuring. . .

The Institute on Climate and Planets is a Research, Science Education, and Minority Outreach Program at the NASA Goddard Institute for Space Studies.

The ICP is funded by the NASA Equal Opportunity Programs Office, Earth Science Office, and Education Division.

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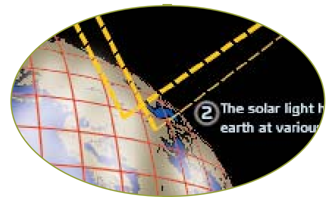
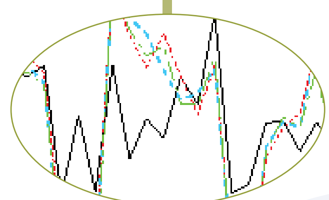
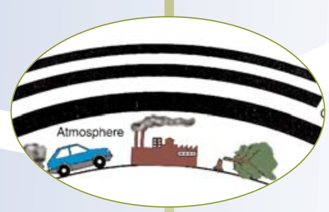
InThisIssue







The ICP Newsletter is released in the fall, winter, and summer.
Please send feedback and comments to: icpnewsletter@giss.nasa.gov.

Research Update

Unfinished Chapters

Summer '98 Contributions of Students, Educators, and Scientists

This past year, the topic of weather was more than just elevator conversation. It was a significant new chapter in earth's climate story, capturing the unprecedented attention of the media. Meteorologists and U.S. weather forecasters from the major networks were invited to the White House. World leaders met in Kyoto, Japan to discuss the progress toward meeting emission standards. There is no question that issues of weather and climate are gaining prominent positions on the national and international policy agenda.

El Niño is now part of our vocabulary, identified by the media as the culprit for nearly every regional climate extreme—sudden and erratic weather changes, catastrophic storms, spring-like weather in winter and, even shortages of strawberries. What makes 1998 such an interesting part of the climate story? This is the year that people (other than scientists) recognized that climate changes that occur in one part of the world have positive and negative consequences for other regions great distances away. In a unique way, this year we experienced how closely connected people's lives are throughout the globe.

Resurfacing in our public dialogue, interest in the earth's climate story has been kept alive by the fascination of people from every academic discipline—poets, writers, scientists, mathematicians, educators, policymakers, historians, computer scientists, economists, business people and journalists. Today, our interest is not only fueled by fascination but also the realization that natural events (e.g., El Niño and volcanoes) and human activities (e.g., industrial and agricultural practices) in one region of the world have far reaching effects on the weather and climate that other people experience.

> Nothing that is can pause or stay;
> the moon will wax, the moon will wane,
> the mist and cloud again,
> the rain to mist and cloud again,
> tomorrow be today.
>
> — Henry Wadsworth Longfellow

Since 1994, students and teachers from New York City schools and City University of New York colleges have been helping scientists at NASA GISS unravel pieces of the Earth's climate story. This summer was perhaps the most productive research summer of the GISS Institute on Climate and Planets (ICP). Many veteran students and faculty were on hand to work with new researchers to understand earth's climate system, regional connections in this system and advance our ability to predict the prospects for future climate change.

They worked on such questions as: Can the "unusually warm Sea Surface Temperature (SSTs) off the West Coast of equatorial South America, near Peru…3000 miles away cause unusual and extreme weather in Florida or the Northeastern United States?" This is a question posed by ICP Oceans Research Team. Ultimately, what the team hopes to contribute to GISS climate research is the identification of long distance relationships (teleconnections) between climate variables, such as atmospheric pressure, temperature and winds, along with the ability of the GISS climate model to reproduce observed behavior.

The unusually warm East Pacific in SSTs during an El Niño change the local atmospheric pressure and can deflect the local winds at the level of the jet stream away from their normal path. Deflection of the jet stream in one place changes the path of storms over the mid-latitudes, including the U.S. If such relationships between topical SST anomalies and the mid-latitude jet can be identified, they can be used to test the realism of GISS's mathematical computer model of earth's climate and improve the simulation of earth's climate system. More accurate climate models may improve our ability to predict events like El Niño and its effects elsewhere around the world and reduce the climate surprises they bring in our lives.

Events like El Niño are the most newsworthy because they have an immediate and recognizable impact on our day to day weather or seasonal climate. More gradual changes that occur on a global scale are not as easily recognized by people other than scientists studying climate change. One such change that scientists are working to understand is the significance of the warming of Earth's average surface temperature over the past hundred years by 1.0° F. Some of the greatest warming is occurring over the tundras of Siberia and Alaska.

in the Climate Story

Summer '98 Research

Oceans

Excerpt from Errol Brown's summer research article: Blue Waters, Brush Fires and El Niño

ENSO forces a mid-latitude response in the GISS GCM, but the shifts in storm tracks differ from the observed change. This suggests that the current GISS model can not reliably forecast the winter time east coast climate response to ENSO.

One of the important results of the Ocean team's research dealt with determining how Earth's climate system responds to SST forcing and chaos. Chaos refers to the natural variability of climate variables such as temperature or air pressure. A forcing is a change in a variable to which the atmosphere responds through changes in variables in the same region or elsewhere as in the case of teleconnections. The team needed to demonstrate that the changes in North America weather conditions during El Niño years were not due to chaos but a response to a forcing, El Niño. Chaos tends to mask the effects of a forcing if the forcing is too small or chaos in a region is too great.

The GISS climate model was run five times over the same time period, 1951-1997. The outputs for each individual run were slightly different due to chaos. The chaos component was found by calculating the difference between how each run varied over time and the average variation of the five runs over time. The latter variation is defined as the response forced by SST anomalies as the forced component. The forcing component was divided by the chaos component at each grid point and the ratios plotted globally for air pressure in the upper atmosphere. This analysis showed that the earth's climate system is more sensitive to forcing in the tropics, but also over certain regions of North America.

However, the mid-latitude regions forced by ENSO in the model did not necessarily correspond to the observed forced response; the observed deflection of the jet stream and mid-latitude storm paths was not perfectly simulated by the model. Thus, the model may not accurately forecast the response to ENSO in certain regions of the U.S.

There is a constant shifting of "winners" and "losers" in earth's changing climate story. A warmer global mean temperature of Earth could bring new resources in some regions while others could experience anything from little change to droughts and floods, or more intense storms. It is this shifting state of affairs that brings into focus the stakeholders in NASA's science mission to understand Earth's climate, reasons for climate changes and its significance to our lives as citizens throughout the world. Too often this mission gets more attention in the form of a politically charged global warming debate rather than in pursuit of knowledge about how the climate system works.

Posing the right science questions can bring a more informed perspective to the climate change debate, an inherently political topic because of the many interests, consequences and costs. Is the unpredictable and intense hurricane season that recently devastated communities in the Caribbean and Alabama merely due to the chaotic nature of earth's climate? Can it be a product of the aftermath of the 1998 "El Niño of the Century"? Could the warming of Earth's global mean temperature be producing more intense storms? All these questions connect the day to day interests we have in weather to our understanding of larger research problems dealing with the how the earth's climate system works.

During strong El Niño years, intense storms can have the impact similar to the ones in 1993 that flooded the Mississippi River and devastated the US Midwest. What nature does on its own to produce such climate events or seasonal changes is important to understand. Another important question, however, is how will human activities that increase global temperatures due to increased greenhouse gas amounts contribute to these changes. This second question was addressed in the ICP Cloud Team's summer research as they dealt with how the frequency of intense rain storms will change in a warmer climate.

The Cloud Team's research shows how science, technology and society are interconnected. By engaging in a writing process to prepare articles that inform the public about climate

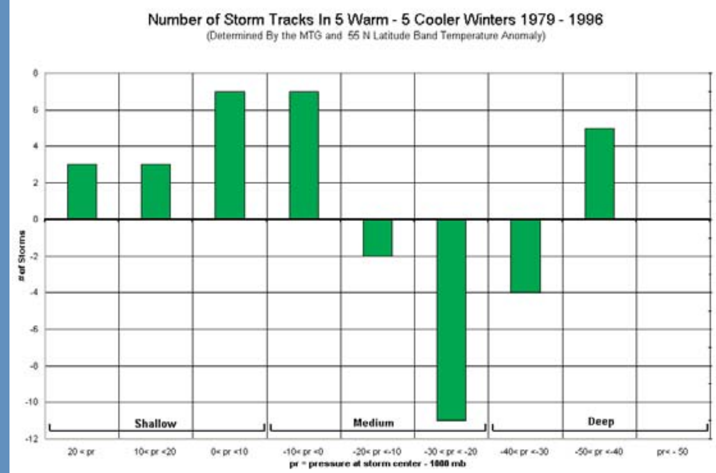
Clouds

Excerpt from Jericco Tolentino and Haidy Pena's summer research article Stormy Weather in the Greenhouse: Profiling the Storms of the Future

According to storm and cloud correlations, extreme storm events may occur more frequently in the future, and those events will be accompanied by increased amounts of high, thick clouds that cause intense precipitation events.

Research findings from R.E. Carnell of the United Kingdom's Meteorological Office and Tom Karl of the National Climate Data Center were the catalysts for the ICP Cloud Team's scientific research. Carnell et al. research using model predictions shows that an increase in global temperatures could lead to more occurrences of intense storms in the future. Karl's analysis of U.S. weather station data indicates an increase in the number of intense rain events in the last hundred years when average global temperatures have warmed.

The ICP Cloud Team studied weather station data for winters from 1979–1996; certain warm winters were selected on the basis that they were representative of the winters expected in the future, and contrasted to cold winters Earth has experienced in the past. Analysis of the differences in storm intensity and frequency between the warm and cold year ensembles was conducted and preliminary results showed an increase in the frequency of the most extreme storms in the warm years.



Deep convective clouds are indicators of intense rain, as they contain large amounts of water, extend high in the atmosphere, and exist where the air is unstable. The team analyzed satellite observations of storm cloud properties and found increases in deep convective clouds for stronger tropical and mid-latitude storms. Their statistical analysis of mid-latitude storms affirms this finding with a 99% confidence level. In comparisons between cloud properties produced in the GISS climate model to those found in the satellite observations, preliminary results show that the model is failing to reliably produce the mid-latitude cloud structures that are found in real world storms.

research, ICP teams realized it was this connection that uniquely motivates people about their NASA research.

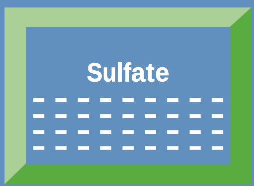
This connection is most direct in research that investigates chemical processes that are altering the composition of the atmosphere and increasing earth's global temperature. To what extent are humans responsible for changes in emissions of aerosols and how do these changes contribute to or possibly mask the actual warming that has occurred this century? In an attempt to improve climate forecasting by identifying and quantifying aerosol composition in the atmosphere, the ICP Sulfate Team assessed how the concentrations of particles in the atmosphere have changed.

GISS's experience involving students and educators in research that addresses real science questions may offer NASA a new perspective for the future. When people are a part of science discovery, either through their personal contributions or through the perception that science is connected to their life, the greatest contribution and purpose of NASA is realized.

Today, NASA's mission to study Earth links science, technology and society in a way that has not been achieved since the Apollo years. The difference in NASA's current Earth science mission is that the scientific debate is shifting away from one that concerns how much temperature is increasing to questions that are prerequisites to informed social and economic decision-making by individual citizens and policy-makers. How significant is the increase in global temperatures over the last 100 years? To what extent are humans responsible for this change? How will this climate change positively and negatively impact the lives of people in the future? (Hansen, 1998).

As humans increasingly populate the Earth, the amounts of many gases in the atmosphere have increased. The growth of industry, dependence on the automobile and increases in agricultural production are all positive indicators of civilization's advancement, but they also increase the amounts of greenhouse gases like carbon dioxide, methane and sulfate aerosols in the atmosphere. To deal with the positive and negative impacts of society's growth, policies of sustainable development are gaining the endorsement of the international community. The ideal is to provide responsible environmental laws while allowing for technological advancement and economic growth. Pursuing this ideal is dependent on climate research.

Several ICP research projects focus on calculating the statistical significance of changes in strong climate forcings, such as ocean phenomenon, clouds and atmospheric gas concen-



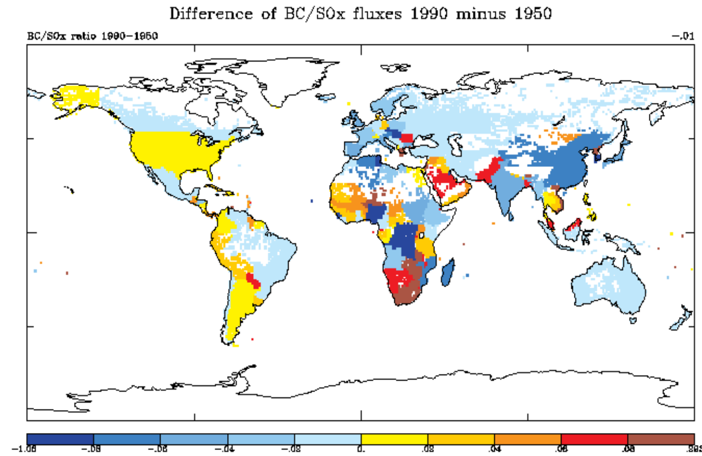
Excerpt from Tom Ferede and Anthony Luckett's summer research article Students in Hot Pursuit of Alleged Culprits

In assessing the net effects of the world's three major consuming and impacting regions (Eastern Asia, U.S. and Europe), the team concludes that there has been a small net increase of aerosol emission, but also a change in the aerosol optical properties.

What do seven weeks of forest fires in Florida during June and July of this year have in common with rush hour traffic? Aerosols. These tiny solid and liquid particles, suspended in the air, are believed to have a net cooling effect on the earth. They originate from both natural and artificial sources.

Forecasting climate is the job of climate prediction models or general circulation models (GCMs), like the one at GISS. GCMs use statistical relationships and mathematical computational methods to simulate earth's physical, chemical and biological processes. At present, the types and amounts of aerosol in the GISS GCM are not representative of the real world. By correcting aerosol information in the GCM, it is expected that the model's over estimation of global surface temperature change will more closely agree with observations.

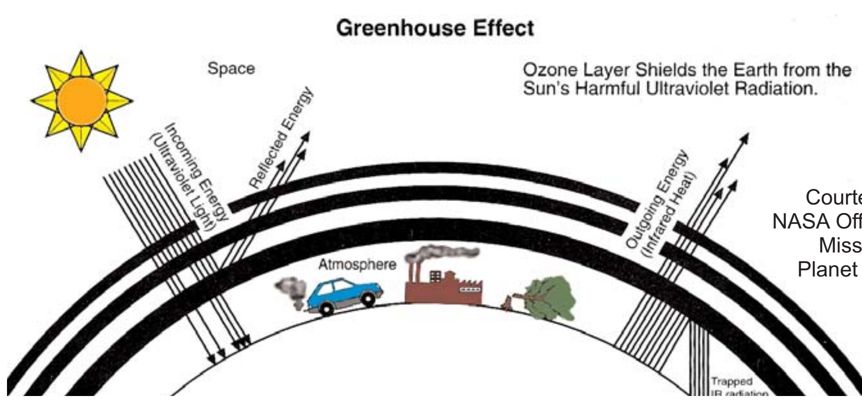
The Sulfate Team applied a method developed by scientists Jane Dignon and Sultan Hameed to establish a direct relationship between the amount of solid and liquid fossil fuel consumed and the amount of emitted sulfur oxides (SO_x)during 1940–1980. Also, the team derived emissions of black carbon (BC)aerosols for the same period. The team drew several conclusions from their research. Sulfur emissions in the U.S. showed an increase between 1950 and 1970, but a decrease between 1970 and 1990, possibly reflecting the enactment of more stringent environmental laws (e.g., the Clean Air Act). In Eastern Asia, emissions of both types increased dramatically, while in Europe this was not the case. How these emission scenarios affect climate is explained by the single scattering albedo, a measure of the relative absorbtivity of aerosol particles in an air mass that is indicative of their net warming or cooling effect. A crude estimate from emissions reveals a global average decrease of the single scattering albedo between 1970 and 1990 of –0.03, which would make the aerosols relatively more absorbing, i.e., produce a warming effect. The emission estimates produced by the Sulfate Team this summer are expected to improve the aerosol composition in the GISS GCM, providing better distribution and trends over decades.



The ratio of BC to SO_x in the atmosphere can tell us the net aerosol effect. How this ratio has changed over time may have more than just climatic implications but also may tell us how human activity has changed. For example, the U.S. witnessed marked decreases in SO_x following the passage of the Clean Air Act in 1970, hence the larger proportion of BC. Furthermore, China's rapid industrialization may account for their large pro-

trations. Some of these forcings occur naturally and some are the direct result of human activities. Changing concentrations of gases in the Earth atmosphere is in part the direct result of human activity.

The question is: *are these changes altering the natural greenhouse effect that sustains Earth's habitability?* The greenhouse effect was originally created by gases from natural sources trapping solar heat in our atmosphere, including water vapor, carbon dioxide and other trace gases, such as methane and nitrous oxide. The energy from the sun is constantly interacting with Earth's atmosphere.



Courtesy of NASA Office of Mission to Planet Earth

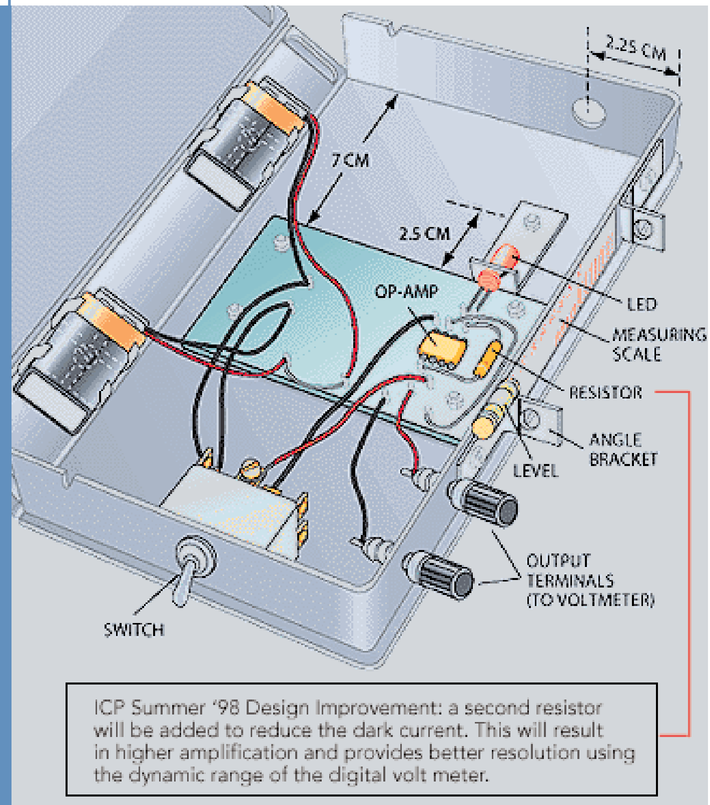
As it travels to our planet's surface, energy is absorbed, reflected and scattered by the gases and clouds it encounters. Once it reaches the surface, it interacts with a variety of land surface features on Earth,

Excerpt from Andre Cassell and Maricela Reyes' summer research article Are Aerosols Only Found in a Spray Can?

First phase of hand-held instruments tests show promising results for use in local scientific measurement campaign.

Aerosols are small liquid or solid particles that can directly interact with incoming solar radiation, either reflecting or absorbing, respectively causing cooling or warming. Small particles are also pollutants that reduce the quality of air and can effect our health. For example, increases in asthma are often blamed on aerosol particles. Natural events, like volcanic eruptions produce aerosols, as do human activities, namely the burning of fossil fuel and changes in land use. Because the distribution of aerosols vary so greatly seasonally and geographically, GISS is establishing a global measurement network of scientific instruments called Multi-Filter Rotating Shadowband Radiometers (MFRSR), as well as a local network of inexpensive, hand-held sunphotometers that can be used by students at ICP schools. The MFRSR instruments measure solar irradiance at different wavelengths to retrieve aerosol properties. Specifically, they measure aerosol optical depth (thickness) and size distribution. The hand-held sunphotometers then provide a spatial context for these detailed measurements, since hand-helds are cheap and can be put in more places.

The primary research objective this summer was to characterize, test and improve the circuitry of the hand-held instrument. Most of the tests concerned the accuracy of the Light Emitting Device (LED) used to measure aerosol optical depth or a quantity usually called tau. When tau is close to zero, light goes through the atmosphere quite well. When tau increases to one, the transmission of light decreases. The team took measurements throughout each day during the summer. Their calculations of optical depth (tau) show that values were generally bigger for the morning measurements than in the afternoon, implying that tau changes during the day. The major finding concerning the instrument viability is that each LED is sensitive to a specific wavelength and the team needs to identify this for each instrument they build. Also, despite the fact that tests of the linearity of the detector circuit using the one over the distance square law were encouraging, further instrument tests over a wider dynamic range are needed for definitive test of the accuracy of the hand-held instrument.



A hand-held sunphotometer.
Adapted from an illustration by Ian Warpole.

including vegetation, ice, desert and oceans.

The seasonal and daily changes we experience in weather are connected to a system of physical, chemical and biological processes connecting earth's oceans, land and atmosphere. The interaction of solar energy with the atmosphere and land surface is just one sub-system of processes at work within Earth's climate system. Yet, it is an ideal example of the motivation for ICP research and the relationships among these projects. Each ICP research project reveals that earth's temperature is the result of many variables absorbing energy in our atmosphere and reflecting it back to space. The relationships between these variables and the sun are what keeps the Earth in planetary energy balance and makes our planet uniquely habitable.

The projects described up until now have used data from a variety of existing sources including: satellites, weather stations, government databases and models. Some ICP research team projects differ because they are concerned with establishing the protocols for a local student climate measurement in New York City. One such project seeks to establish viable data records for understanding urban climate in terms of the distribution and significance of aerosols.

In opening remarks to the 1998 ICP Summer Institute, NASA GISS Head, James Hansen stated that "one of the reasons we initiated this research and education program (ICP) was our perception that we (scientists and educators) don't always do a good job of explaining and communicating how science really works." One way to address this challenge is being modeled by the ICP—directly involving students in collecting climate measurements where they live, analyzing the data they retrieve, interpreting results to contribute to NASA's climate research program and developing interesting research questions of their own.

At the heart of our interest in weather and climate is its relation to our past, present and future lives. Rarely does a topic so inherently weave the story of life on earth. From the past climate changes that evolved and destroyed life to present day debates over the significance of human activities on our climate habitability, this topic directly and indirectly impacts our daily lives. Can we know today what earth's future climate will be like? This is why GISS is developing a climate model—to predict future climate under different climate "scenarios" and better understand the impact of human activities and natural climate variability that force climate changes.

According to GISS scientist, George Tselioudis, "One common objective of all ICP projects has been to put the model through one hard test after another. ICP researchers used satellites, weather stations and even their own instrument observations to study diverse phenomenon and the connections between them, and then challenged the model to see how well it can reproduce them. The differences that they unveiled revealed, like the lack of extensive mid-level cloud decks in the models mid-latitudes, will be the focus of GISS scientists efforts to improve the model's view of the past and present and its ability to foresee the future."

Continuing to write earth's climate story in a responsible and objective way requires informed decision-making about climate change policy and research. It also needs a dialogue among people that possess and understand scientific evidence and perspectives about the role humans are playing and the way climate changes naturally on its own. This presents a unique challenge to NASA—sustaining the high quality climate research conducted by its scientists while connecting the climate story to the lives of people, either through their involvement in school-based research or indirectly through their perceptions of the Agency's vision and progress.

How well we make connections between the past, present and future chapters of Earth's climate story may be the determining factor in NASA's ability to meet this challenge. The past provides a standard to assess the norms and consequences of climate change. Present climate is our immediate concern and a measure of how things have changed. Our future is the prospects for climate to the degree of confidence we have in predictions made by GCMs combined with the common sense we apply to interpreting these predictions with past and current hindsight. Together, these perspectives are needed to answer the questions that drive this story. *—CH*

Contributors to the Research Update and Highlights: GISS Scientists—George Tselioudis, Jim Hansen, Ina Tegen, Ron Miller, Jennifer Phillips, Elaine Matthews and Brian Cairns.

ICP FALL/WINTER ANNOUNCEMENTS

November

Attention Students: Requests for Student Internship proposals will be distributed.

Attention Faculty and Scientists: Ballots will be distributed to nominate ICP educational products that you believe represent the best materials developed to date.

December

A process will be set up to assess nominations of ICP educational products and select 1–2 candidates for developing into a package for NASA Earth Science review.

January

ICP Annual Report and Evaluation (June 1997–May 1998) distributed.

Faculty-scientist teams selected to develop education products.

February

Recruitment for 1999 Summer Institute begins.

1998 ICP Journal of Student Research distributed.

March

Next ICP Newsletter.

ICP WEB Highlight

http://icp.giss.nasa.gov/education/cloudintro

Introduction to Clouds: Preparing for a Research Project

Clouds are just one part of Earth's climate system —an important part nonetheless. An interactive module for learning and teaching about clouds is available to the ICP school research network via the ICP web site at

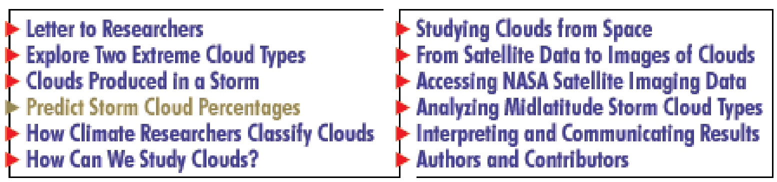
http://icp.giss.nasa.gov/education/cloudintro/

The module was developed to prepare students and teachers for participation in ICP clouds research. For students to become motivated and gain knowledge, it is important that they understand their project and also its scientific relevance and context in climate research.

The Introduction to Clouds module can be used in a classroom or lab setting with access to computers and the Web. Students work individually or in small groups. Different types of clouds, their properties, satellite observation, data collection, and analysis techniques are introduced. There are applications for teaching concepts and skills addressed in science and technology courses as well. Students work with satellite data to study the types of clouds formed in storm systems and understand their influence on regulating Earth's temperature. They also gain experience developing a hypothesis and testing how well it represents the physical world. This article describes the main features of the module.

A PROBLEM TO BE SOLVED

A letter to the researcher presents questions that guide the exploration. Students are asked to "investigate actual scientific research data on clouds and storms, and make observations and interpretations available to NASA research scientists for review." Their work could help determine what may happen to storm clouds if Earth's climate is changing, and consequently, how Earth's temperature may be affected.

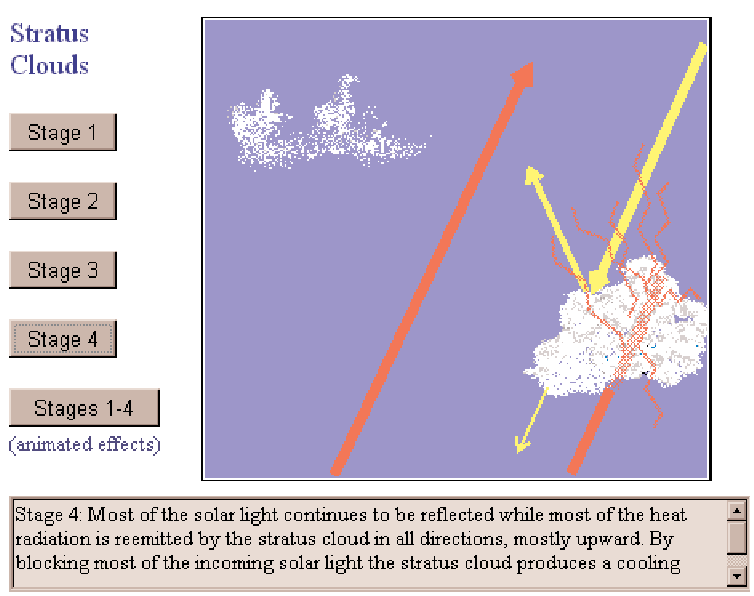


Navigation scheme for the "Introduction to Clouds" module.

MAKE YOUR INITIAL HYPOTHESIS

Two extreme types of clouds, cirrus and stratus, demonstrate how clouds interact with solar and terrestrial radiation, and depending on their type, either cool or warm Earth's surface. The student can view four stages of the interaction for each cloud type, which illustrate the importance of two properties of clouds: optical thickness and cloud top pressure.

The student is asked to hypothesize which of the nine types of clouds (images of which are presented) are common in storm systems. Choices are made on the basis of the cloud properties previously introduced. He/she then predicts percentages of chosen storm clouds using an interactive fill-in worksheet. The worksheet requires the student to be mathematically and typographically correct and is persistent in achieving accuracy. To



A stratus cloud interacting with solar light and terrestrial radiation.

Traditional Cloud Classification

Cirrus ___ %	Cirrostratus ___ %	Deep Convective ___ %
Altocumulus ___ %	Altostratus 24 %	Nimbostratus 7 %
Cumulus ___ %	Stratocumulus ___ %	Stratus ___ %

Check Total | Print Hypothesis | Clear Entries

Worksheet for predicting storm cloud percentages.

NEW YORK STATE STANDARDS ADDRESSED

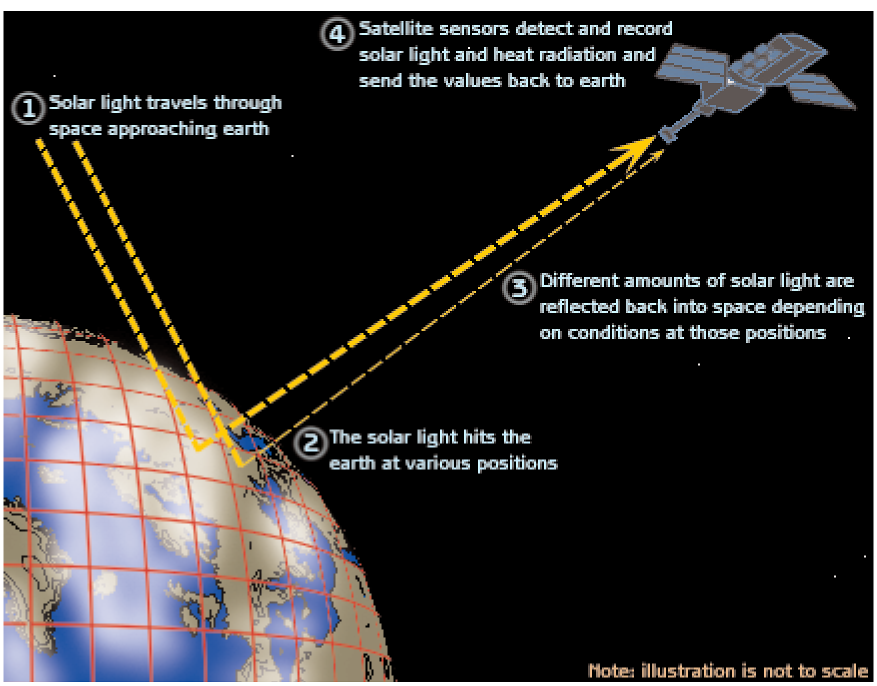
Standard 1:	Analysis, Inquiry, and Design
Standard 4:	Physical Setting
Standard 6:	Connecting Themes (science, technology, and society)

complete this initial hypothesis, the student proposes a method for studying clouds in a storm system covering a large area. Predictions can be saved or printed to compile a journal of the investigation.

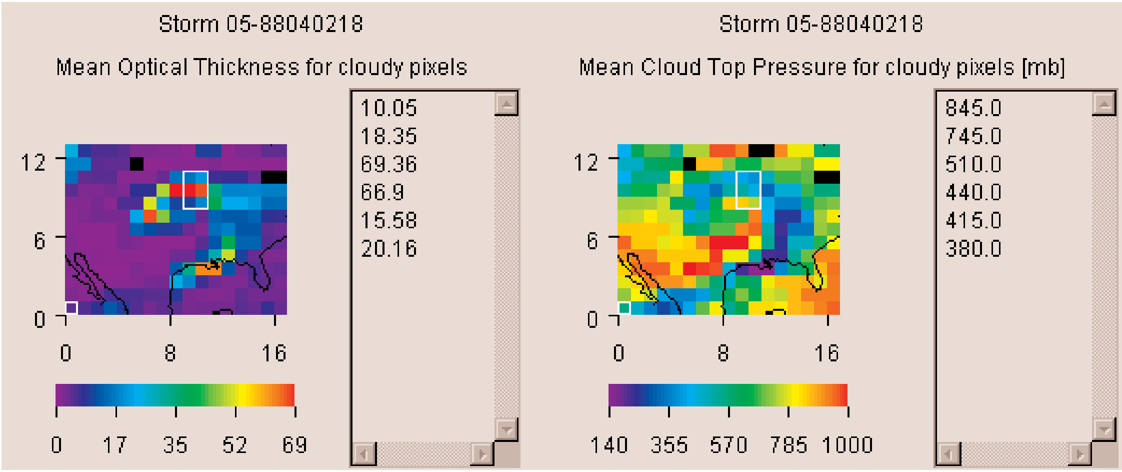
FROM EARTH TO SATELLITES AND BACK TO EARTH

Where do all the data on clouds come from? And what do they mean? Research using cloud data is more meaningful to a student if he or she is able to answer these basic questions. More complex questions like "What is the role of clouds in climate change?" and "How do clouds relate to storm dynamics?" can then be approached with a better understanding.

The steps involved in cloud data observation, collection, processing, storage, transmission, and analysis are presented next. A series of images (with animation) illustrate how an orbiting satellite detects sunlight reflected by the earth's surface and records measurements that are transmitted back to Earth. The data is processed and graphed by climate research scientists. Imaging tools are used to produce data maps by assigning a range of colors to numerical values enabling convenient data analysis. Color images can also be converted to grayscale images similar to those used by weather reporters on television. Students can download satellite maps of North America collected by the Geostationary Operational Environmental Satellite (GOES)-East, including current images of the earth.



Satellite collecting information from reflected solar light.



Data viewer Java applet written by Jose Alburquerque.

Data values for mean cloud optical thickness and mean cloud top pressure appear upon selecting corresponding points on the color maps.

A TASTE OF DATA

A Java applet visualizes data from the International Satellite Cloud Climatology Project (Mean Cloud Optical Thickness and Mean Cloud Top Pressure) for a storm that occurred over the United States in April 1988. The student selects data points on two color maps and is asked to compare values with a cloud classification table introduced earlier in the activity. He/she then determines the types of clouds that are seen in the given midlatitude storm. Results are compared to the student's original hypothesis.

Next, the student is asked to select a section of the data set, transfer it to a spreadsheet program, and graph the values, producing a final result that determines the true percentages of cloud types in this (typical) midlatitude storm.

TELL ME YOUR STORY

The student's final task is to compile a report of what he or she learned from the initial hypothesis, graph interpretation, class discussions, and limitations of the investigations including possible sources of error. A web page of the report can be produced using a form provided.

STUDENT RESEARCH PROJECTS

After successfully completing the activity, students may be expected to take on independent research projects such as:

- How are tropical storm clouds different from midlatitude storm clouds?
- What kinds of clouds form along cold and warm fronts in a storm?
- How is storm strength related to cloud type during ocean or land storms?
- What is the relationship between seasonal changes in storm dynamics and cloud properties?

ABOUT THE MODULE

Originally created during the 1997 summer program at the NASA Goddard Institute for Space Studies by the ICP clouds research team, the module has since undergone revision. It is now a complete set of instructional web pages and scripts for learning/teaching about clouds. Teachers and students in the ICP school network are invited to utilize this web module.

Feedback from your experience is welcome and can be sent to the authors listed on the ICP web site.

— LK

TERMINOLOGY

- Cloud Top Pressure: the amount of pressure on top of a cloud, as inferred from satellite measurements. As elevation in the earth's atmosphere increases, the pressure decreases. So, if a cloud has a low pressure on its top, it is relatively high in the atmosphere and vice versa.
- Optical Thickness: the reflectivity of a cloud based on the amount of water it contains. Higher water content clouds have greater reflectivity and are called more optically thick.
- Midlatitude Storms: storms that form along fronts (masses of warm and cold air) and occur in the 30 to 60 degrees latitude region.
- Cloud Top Temperature: the temperature on top of a cloud, as measured by a satellite. As elevation in the earth's atmosphere increases, the temperature decreases. So, if a cloud has a low temperature on its top, it is relatively high in the atmosphere and vice versa.

SCIENCE INQUIRY SKILLS

- Designing an experiment or research task
- Formulating hypotheses
- Discussing relationships between variables in a system
- Organizing data
- Making predictions about data
- Interpreting a graph
- Explaining possible source of errors in data
- Investigating limitations of an analysis

Summer '98 Research

Storms

Forcings and Chaos-Storms Team: excerpt from Alexandra Estrella's summer research article, El Niño and Winter Storm Observations and the GISS GCM

The GISS GCM's response to El Niño is masked by the effect of chaos. Storm tracks are a useful diagnostic tool for analyzing the GCM.

For residents along the East Coast of the United States, coastal storms often bring hardship through their combination of wind, rain, snow and tides. Therefore, it would be useful to understand why storms frequently batter the coastline one winter, while leaving it alone another. In particular, this research team investigated whether El Niño, a large scale warming of the eastern and tropical Pacific Ocean, affects winter storms' paths ("storm tracks") along the U.S. East Coast and Gulf of Mexico. This big climate forcing affects the atmosphere like a big kick to a spinning top. However, researchers still don't fully understand how this "big kick" changes climate, especially on the scale of winter storms.

This Forcings and Chaos sub-team examined the effect of El Niño on two variables: the frequency of winter storms in actual observations, and also the frequency of storms simulated using the GISS GCM. The research aimed to distinguish in the GCM the influence of "big kicks" from climate forcings, like El Niño, from "chaos" or big changes in outcomes due to small differences in the initial values of data.

Results using observational data show that El Niño is statistically correlated with more winter storms along the Eastern and Gulf Coasts of the United States. However, using four very similar runs of the GISS GCM, the sub-team found generally insignificant correlation between El Niño and storms, and also between one model and another. The differences in the model vs. model comparisons are a sign that the model's response to El Niño is being masked by the effect of chaos. It also seems that chaos causes the model to respond differently to El Niño than the real atmosphere.

Methane

Methane Research Findings: excerpt from Teresa Smith and Harvey Augenbraun's summer research article, The Growth Rate of Atmospheric Methane Concentrations is Decreasing

Concentrations of atmospheric methane have been rising for decades but the rate of growth is slowing down.

Methane is a potent greenhouse gas found in small concentrations in the earth's atmosphere. It warms the earth by absorbing infrared (heat) energy emitted from the earth's surface. Although methane exists naturally in the atmosphere, it has more than doubled in the past 200 years in part as a result of human activities related to agriculture and fossil fuel use (coal, natural gas, and oil). Atmospheric concentrations of methane have been increasing for decades but the rate of growth has been declining particularly in the 1990s. Exact causes for this decline are not known but result from declines in source emissions, increases in chemical sinks (processes that remove methane from the atmosphere), or a combination of the two. In order to assess the potential role of several major anthropogenic (human-induced) methane sources to the observed decline in growth rates, the methane research team estimated global methane emissions from three major anthropogenic sources (domestic animals, rice cultivation, and landfills) for five-year increments from 1965 to 1995. The estimates relied on country statistics from the United Nations Food and Agriculture Organization (FAO) and internationally-recognized emission methodologies of the Intergovernmental Panel on Climate Change (IPCC).

The research team's results show emissions from domestic animals increased from 76 Tg in 1965 to 89 Tg in 1995, with an actual decline in emissions between 1990 and 1995. Harvested rice area and associated methane emissions increased about 20% over the 30 year study period. Increases between 1965 and 1970 were close to 8% but dropped to about 2% between 1990 and 1995 reflecting a slower growth rate. The results also suggest that domestic animals and rice cultivation are potential contributors to the declining rate of growth observed for atmospheric methane concentrations. However, methane emissions from landfills, driven by a 70% increase in the world's population in the last 30 years, appear to be increasing at a fairly consistent rate of 7% per five-year period and therefore are not contributing to the declining growth rate of methane.

Earth Climate Course

This is the first in a series of articles to evoke discussion among scientists and educators about the development of the ICP's Earth Climate Course (ECC). The focus of this article is the evolution of the ICP faculty's education beliefs that emerged from their continuing research experiences, collaboration with GISS scientists and classroom field-testing of research-based curriculum. Future articles will focus on the overall ECC content design, approach to science learning and examples of educational activities.

When preparing science lessons, teachers will be able to draw from various modules of the ECC to link NASA's earth system science research and classroom instruction. Since its inception in 1994, ICP faculty and scientists have been producing education materials and instructional strategies designed to offer teachers practical ways to establish this link.

This missing link or bridge, between real science and the science classroom that has driven education reform since the turn of the century. Why are people who want to improve science education preoccupied with erecting this bridge? One reason is that we want students to have science experiences that reflect the nature of real science inquiry where problems are open-ended, ill-structured and solved in an iterative way. We want them to be adept at systems thinking, making links between environmental, ecological, and social issues. (Kruckeberg and Cushing, 1998).

We also want students to be aware of the current state of our science understanding, how it evolved and its relationship to society. The ICP's new initiative to develop the ECC aims to synthesize the collaborative research experiences of students, faculty and scientists into a course that addresses these outcomes for student science learning.

THE ICP MODEL
Creating bridges from
NASA GISS Research Community
ICP School Network
Earth Climate Course Teacher Education

Before bridges between science and education can be developed it is important to know: *What are the aspects of real research that are most useful to students in the science classroom?* Even more challenging and perhaps more important to science teachers is answering the question: *How do we translate these experiences into educational materials and instructional strategy teachers can practically use in the classroom?*

A pre-requisite to involve students and faculty in answering these questions is their participation in research. This model views education and science as dynamic processes that benefit from the ICP School Network—where faculty test the ideas to translate research into classroom applications. The iteration between science and education is the foundation for "ICP Education Products"—education materials and instructional strategies for the classroom—that emerge from implementing the ICP model.

These fundamental beliefs justify the three ICP model development phases shown in the diagram, on the right *(page 13)*. Each phase is dependent upon the foundation built in the former. Ultimately, the program components in each phase are expected to interact in a single feedback loop and impact an increasing number of students. It aims to create institutional and sustainable capabilities in a school building, the intended target of reform.

COURSE FOR TEACHER EDUCATION

PHASE 1: Create a community of scientists, faculty and students and develop capabilities to build the research-education bridge through shared experiences

The ICP model draws on the active involvement of teachers and scientists: their creativity, commitment and energy. Thus, scientists and teachers are like artists in the science reform process who create the canvas to teach science in a way that better represents how science works. While they are creating a new work, they are also guided by the current national and state education goals and research.

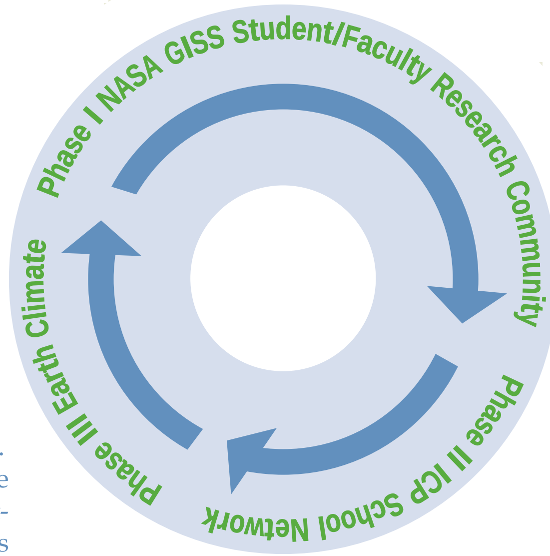
GISS established contributing roles for educators and students in its research program over the summer and throughout the academic year. This produced working relationships and developed knowledge and skills that were shared among students, educators and scientists (about NASA's climate research). Extremely high levels of participant retention enable the two expected outcomes of this collaboration to be achieved over a three-year period. Faculty and students view themselves as part of the GISS research community and gained capabilities to lead research project activities with scientists as facilitators. Also, ICP has the commitment of the schools and colleges to serve as test-beds implementing research projects and education activities in research classes, science courses and after-school programs.

PHASE II: Establish ICP School Network relationship with GISS to develop, field-test and evaluate research-motivated curriculum, including the Earth Climate Course

The ICP School Network component provides a place within a school building for faculty to field-test education materials and instructional strategies, as well as revise them based on classroom experience.

> If we are interested in education that develops the abilities of each student, teaching needs to be a "fluid and complex" process" where teachers actively participate in decision-making that impacts their classrooms (Snauwaert, 1993).

To varying degrees, teachers in the ICP School Network have been engaging in such a process, applying real research experiences to teaching science and using GISS scientists as a resource. In the form of educational



modules, web-based activities and research projects, the ICP is being integrated into the science curriculum of 18 high/junior high schools and colleges. Campus-based research is an important outcome that is gradually being acheived through the increasing ability of ICP faculty to lead projects, and the commitment of GISS scientists to serve as advisors. A second important outcome is the development and integration of curriculum motivated by research that addresses New York State science standards. The short-term goal is to identify 1–2 ICP education products for development into an education package to submit in NASA's Earth Science peer review. The ultimate goal is to develop an Earth Climate Course that synthesizes the beliefs, research experiences, materials and instruction that have resulted from the ICP.

PHASE III: Develop the ECC as teacher education initiative and establish collaboration with schools of education and high schools for implementation.

The Earth Climate Course for teacher education is the final ICP model component to bring about science reform. It aims to link schools and colleges by having classroom teachers assume some of the responsibility of teacher preparation, a proposal that is gaining popularity (Weiner, 1993).

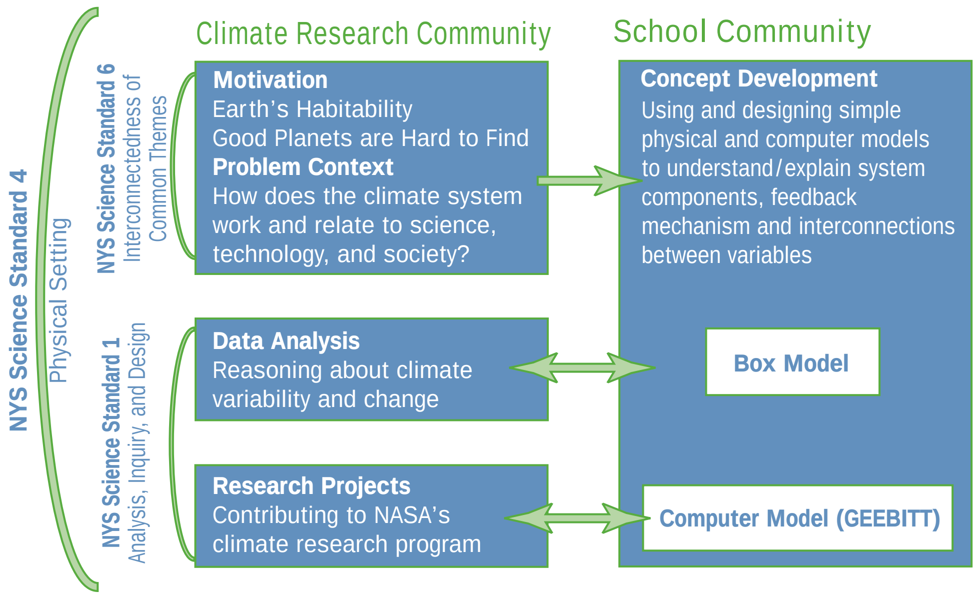
A proposal to jointly offer the ECC to education students and teachers will be presented to Columbia University and City University of New York. The current plan is to hold the first course semester at the school of education, engaging teams of education students and teachers in short research projects and activities associated with the four ECC modules. During the second semester, teams will implement their conception of the ECC in the classrooms of teachers and attend class meetings to discuss ECC implementation. Eventually, a select group of ICP teachers will deliver the ECC in a series of short courses, establishing their school as a teacher education institute for New York City teachers. ECC will seek the endorsement of the New York Board of Education, State Department of Education and NASA Education.

FIRST STEPS TO DEVELOP THE ECC: What are the aspects of research that will most benefit students?

One of the first steps in the development of the ECC is to define a coherent statement of what the research community has to offer science education. Each year in the ICP faculty, students and scientists voice their opinions on this subject and we have seen an evolution of education

Nothing is perfect (in research), so when you get a result, there are always limitations and a chance that the result is not valuable.
— ICP Student

ICP Earth Climate Course Instructional Approach:
Bridging the Climate Research and School Communities



This model is guiding the development of the Earth Climate Course. It evolved from the collaborative research experiences of students, faculty and scientists involved in the ICP. The remainder of this article describes the justification for its development and structure.

products that reflect their changing views. In ICP's beginning the overriding benefit was the opportunity for students to contribute to "real" scientific research, reasoning about the meaning of "real" science data in the context of climate variability and change. The open-ended nature of these problems and relevance to the habitability of our planet distinguishes them from more traditional science problem-solving at school. The uncertainty of outcomes associated with climate problems is also unique and more acurately reflects the nature of the problems students will deal with in their lives.

As student, faculty and scientist research experiences evolved in conjunction with trial implementation of the ICP curriculum, so did the conception of what aspects of research most benefit students. ICP faculty member Mitch Fox summarized concerns raised about applying the summer research experience in the classroom in the following way :

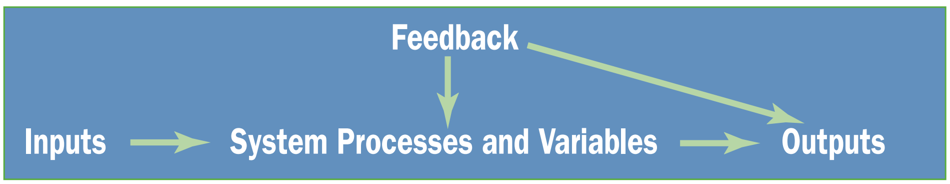
> *Students are provided with the problem, the methodology and the datasets… explanation of basic concepts is done on a need to know… understanding of the interplay of the factors in the earth system takes a back seat to the necessity to produce research results. At school, students will be best served if they begin (research) with familiar concepts and expand their understanding* (Curran, Gandolfo and Finnerty, 1998).

With these evolved perspectives in mind, our faculty is in the process of adjusting the focus of the school-based ICP. The new emphasis is on what students can gain from the process of science inquiry motivated by research dealing with Earth's climate system. Understanding how the system works will require students to learn about subsystems that influence climate, the variables with these systems and the interactions that can affect Earth's climate. Focusing on a better ways to represent real science inquiry in the classroom will give students a chance to question methods and results. It will call upon them to repeat and revise methods, organize and re-organize data and discuss their results in relation to science, technology and society. The expected outcome is for a science class of young researchers to share their state of understanding with one another and negotiate a consensus around a certain view, determining the most important results and their significance.

THE MESSAGE OF THE NEXT GENERATION ICP PROJECTS FOR THE ECC

The newest ICP research, the sunphotmeter and pollen projects, engage students in taking their own measurements of climate as a means to provide more "concrete" experiences that directly consider the origins of data. Collecting their own data, raising questions of their own and designing experiments are viewed by the majority of faculty as vital experiences for

Research is understood within the context of what other researchers are doing and in the context of its larger significance.
— GISS Scientist



students, even pre-requisites to developing the necessary conceptual understandings to make meaningful research contributions.

As an example, the sunphotometer project is concerned with understanding the aerosol effects on climate. By using a hand-held instrument students are able to take local measurements of a single channel wavelength of solar radiation. The student-constructed hand-held instrument becomes a research tool for students to understand the radiative properties of aerosols, the behavior of light and the angle of insolation's affects on sun intensity. The project's experimental aspect and aim to improve instrument design are new features in ICP research that are expected to give students a feeling of ownership. It is also expected to lead to more concrete understandings of science concepts through the trial and error of measurement under different climate conditions.

Understanding climate as system of interconnected processes that vary in response to human and natural factors is another new emphasis in ICP. Using simple models of these responses is seen as a valuable way to understand underlying science concepts, as well as to realize the limitations of models to study the complexity of the climate system. ICP faculty members Pat Cushing and Robert Kruckeberg developed the working schematic below this past summer as a foundation to guide student-modeling investigations. Using this model, students construct perspectives and understandings of Earth's climate system in relation to inputs (forcings like solar radiation), climate processes and variables (like temperature) and resulting outputs or responses (possible changes in temperature).

The newest developments offer students research tools to model aspects of climate system and conduct controlled investigations, simple enough that "novice" researchers can ask questions and design more advanced investigations. One of these tools is a physical "Box Model", developed by Cushing and Kruckeberg. Using a plastic bread box, a light source, a solar cell, volt meter and various materials to represent earth surface features (e.g., dark/light gravel, green fish tank moss, water), students can conduct experiments to learn how different surface features affect the amount of energy absorbed by the sun. Teams of students can represent these affects for different regions of the globe by the materials they choose to include in their Box Model.

Inquiries with the Box Model aims to give students a chance to design their own experiments and develop hypotheses to determine the affects of varying energy inputs, as well as calculate the percent reflectivity of different surface features based on the readings from the volt meter. Through the interpretation of their results they can answer several questions about reflection and absorption, and deal with the current issue of deforestation.

Another of these tools is an Excel-based climate model called Global Equilibrium Energy Balance Interactive Tinker Toy (GEEBITT). This model was developed by GISS scientist Andy Lacis and converted to Excel format by ICP faculty member Chris Petersen with the intention of helping students understand radiative processes in climate studies. GEEBITT uses the software program Excel as the interface. GEEBITT is meant to be a bridge between introductory, skill-building activities and real research using the GISS climate model (Petersen, 1998). A series of activities guides student modeling with GEEBIT, beginning with an activity where students offer their current understanding of the distribution of surface features (water, snow/ice, vegetation and desert/arid) for an designated region of the world. The next step is for students to investigate *"How does the selection of different surface features affect the temperature of your model?"* Students can investigate this question through experiments using the Box Model. GEEBITT can be used for further study of the Box Model results and to study the regional land surface and atmosphere features students derived. These activities are warm-ups to student investigation of actual climate scenarios that students can investigate that relate to possible ways the climate may change.

Working with the GEEBITT model students can enhance their critical thinking skills by *consider-*

ing the ramifications of their scenarios and the possible chain reactions In addition, they will be able to *define their own problem (self-generated scenarios), propose model testable hypotheses and design their own model experiments* (Petersen, 1998).

Some the specific skill-building aims of modeling investigations identified by Cushing and Kruckeberg are:

1. Constructing graphic representation of the complex relations between variables in a system
2. Establishing cause and effect relationships between variables in a system
3. Understanding the effects of feedback mechanisms on systems behavior
4. Defining the conditions under which a system model accurately represents real system operation.

ICP's new emphasis on applications of climate research in guided student experimentation, modeling and systems thinking has strong connections to the New York State Science Standards. In particular, the evolving education activities in ICP address **Standard 1:** Analysis, Inquiry and Design and **Standard 6:** Interconnectedness and Common Themes. The continued focus on Earth's climate system is naturally linked to objectives in **Standard 4:** Physical Setting.

As we enter our fifth program year, what we do know is sincere efforts to bridge the gap between science research and education require a significant amount of learning and relationship-building among professionals from both these communities. We also know that developing curriculum to achieve this end is an iterative process that requires active dialogue between scientists and educators and classroom field-testing. Finally, the progress of the ICP demonstrates that creating institutional capabilities at the school building level produces sustainable and systemic changes because teachers are the most important variable in the education reform.

This final point seems obvious, yet the school building level and teacher do not represent the majority of investments in educational reform. In David Tyack's book, *The One Best System: History of American Urban Education*, he says:

. . . the basic task of teaching the children of the cities will still depend, as it has in the past, on those with full-time and long-term commitment, especially the teachers. For real systemic change, teachers should be viewed as decision-makers in their individual classrooms, not merely implementers of educational materials and instructional strategies for national, state or local reform.

The revised ICP model for bridging the gap between science research and education is built on this belief.

The ECC research and development effort is dependent on feedback from students, faculty and scientists to ensure that it reflects the research/education experiences, beliefs and lessons learn from NASA's investment in the ICP. In particular, ECC development in the nation's largest urban pre-college and college school systems, New York City, is expected to integrate the unique perspective of urban educators into this science curriculum. — *CH*

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B. Curran, R. Gandolfo and K. Finnerty
P. Cushing and R. Kruckeberg
C. Petersen
M. Fox

FEEDBACK:

Electronic bulletin board via the ICP homepage at:

http://icp.giss.nasa.gov/

In research you continually have to make hypotheses. Even hypotheses that don't apply to research findings in the data are an important result.
— ICP Student

Impacts

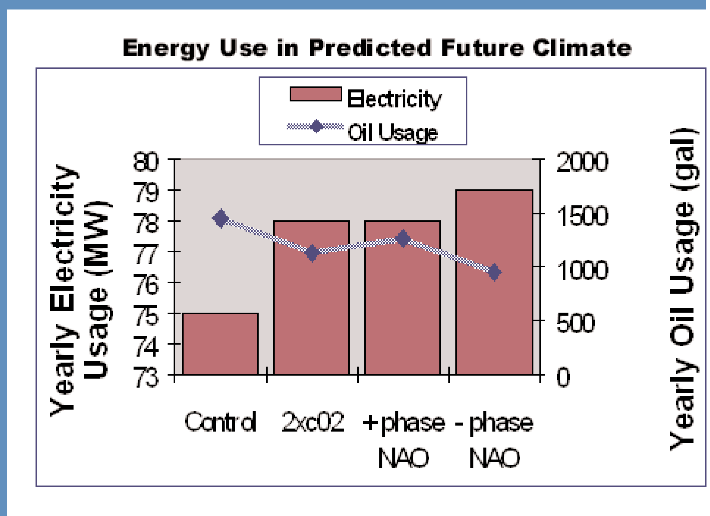
Impacts Research Findings:
excerpt from Caryle Ann Francis' summer research article
Is Global Warming Burning a Hole in Your Pocket?

Natural variability along with the influence of a double Carbon Dioxide climate translates into periods of much lower winter heating costs and higher summer electricity use, alternating between periods of little to extreme change.

The ICP Climate Impacts team's research effort focused on what impact a warmer future climate will have on the local supply of water and energy use in New York. A warmer climate may have benefits in terms of lower heating bills, but may also put added pressure on water and summer electricity use. Potential impacts are important to setting policies for future technological development.

The team's first results show what the NY climate might be like in a future climate run with the GISS GCM where carbon dioxide doubles by the year 2030. This experiment projected that air surface temperature increases 3.2 to 5.3 degrees Celsius over current conditions in the NY region. Precipitation under the same scenario ranges from an increase of about 50 mm per month in the spring and summer to a decrease of approximately 15 mm in the autumn. The team then considered positive and negative phases of the large (natural) ocean forcing of the North Atlantic Oscilliation (NAO) that, depending on its phase, can influence precipitation and temperature in the northeastern United States.

Using climate scenarios based on a double Carbon Dioxide world, and ranging from positive and negative NAO phases in their experiments, the team studied the impacts on water and energy. The first scenario employing the Ea-Quip model, found that in a warmer climate homeowners would spend less to heat their homes in winter but summer AC use would extend into the autumn. Pressure on water use fluctuated in a similar way as energy, between moderate and extreme impacts. While the climate scenarios used are simplified because they do not consider interactions between the NAO and global warming, this study provides the ground work for more advanced investigations.



Student Profiles

Rosa Andujar

ROSA ANDUJAR is a senior at the High School for Environmental Studies, in Manhattan, New York. As a new member of the Forcings & Chaos team during the 1998 ICP summer program, her research focused on climatological model studies. Under the guidance of Drs. Jim Hansen and Lionel Pandolfo, she compared two versions of the GISS general circulation model having different vertical resolutions. This fall, she is scheduled to present her ICP research to her school. Rosa won the 1998 Barnard Essay Contest, and was a participant in the Third Millenium Future Advocates Program. She was a guest on CNN's Talk Back Live in April, and was listed in Who's Who Among American High School Students. She hopes to attend college at a prestigious institution like Columbia or Harvard, and eventually obtain a doctoral degree. Her career goals have shifted towards a research environment after her experience at GISS this past summer and she hopes to work in scientific research. Her hobbies include reading, writing, and swimming.

Rashele Cross

RASHELE CROSS is a junior at Townsend Harris High School, in Queens, New York. She started at the ICP this summer as a member of the Radiation (Atmospheric Remote Sensing) research team led by GISS Scientists Drs. Barbara Carlson, Brian Cairns, and Andy Lacis. Her project involved building, testing, and improving hand-held sunphotometers to measure the intensity of sunlight to study atmospheric haze. She presented her research at the 1998 ICP summer conference held in August. Her experience at GISS has helped her relate science to her everyday life. Rashele is on the honor roll at school and is also a member of Arista, and Archon (service honor society). She plans to attend college and pursue pre-medical studies and has already done volunteer work in a hospital, and after-school programs. She enjoys her dance classes, singing in choir, and reading.

Sharika De La Oz

SHARIKA DE LA OZ is a senior at A. Philip Randolph High School, in Manhattan, New York. She is a student researcher on the ICP Clouds summer '98 research team. Her project, guided by Dr. George Tselioudis, attempted to determine the relationship of the strength of a midlatitude storm to the amount of rain clouds produced by the storm. She presented her work at the 1998 ICP summer conference, and plans to work on a Westinghouse project this year. At school, Sharika has been on the Principal's Honor Roll from 9th through 11th grade and has achieved Excellence in Spanish, Biology, and Chemistry. Her presentation on cloud types in midlatitude storms at City College of New York won an award from the New York Academy of Science. Her future plans include attending Brown University, majoring in Computer Science, and eventually working towards a doctoral degree. Her career goal is to become a scientist. Sharika likes to read and write poetry, and enjoys roller-skating.

Donna Hope

DONNA HOPE is a junior at Rensselaer Polytechnic Institute, and has been a student researcher at the ICP from 1995 to 1997. Her research in summer '97 involved the study of wetlands to determine if they help prevent flooding and how wetland eradication may have contributed to an increase in flooding. A former member of the Climate Impacts team, she worked with GISS Scientist Dr. Jennifer Phillips. She hopes that her project will serve as incentive to protect natural ecosystems that are rapidly being depleted by human development. Donna was awarded a Culturally Diverse Institutions Undergraduate Student Fellowship by the National Center for Environmental Research and Quality Assurance of the Environmental Protection Agency (EPA). She has the honor of receiving full college tuition, a stipend, an internship at the EPA this past summer, and an academic year research opportunity with a college faculty sponsor. Congratulations Donna!

Ben Lewis

BEN LEWIS is a senior majoring in Chemical Engineering at the City College of New York, in upper Manhattan. He has been a student researcher at ICP during the 1996 and 1998 summer programs. His research this summer on the Aerosol Emissions team led by GISS Scientist Dr. Ina Tegen, focused on the effects of anthropogenic aerosols on the globe and their representation in present climate models. He presented his work at the 1998 ICP summer conference with the rest of his team members. Originally from Trinidad, Ben graduated from Tranquility Secondary School in 1992, and now plans to continue studying towards a Master's degree at City College. This soft-spoken young man says his experience at GISS has made him more aware of the environmental issues that are a result of human activity. Ben's interests include listening to music, and the game of Chess.

Raysa Rodriguez

RAYSA RODRIGUEZ is a junior at the Bronx High School of Science in New York. As a first-time student researcher on the ICP summer '98 *Oceans* team lead by Dr. Ron Miller, she studied El Niño and its effects on weather patterns in the United States. She participated in her school's science fair for the 1997–1998 year and is now starting research for the Intel Westinghouse Science Competition 1999–2000, and the Duracell competition. Raysa feels her experience at GISS has given her great confidence in her abilities, especially working with computers. She feels she could now do anything if she set her mind to it. She hopes to attend college at Air Force Academy, achieve a double major in Computer Science and Economics, and eventually pursue a doctoral degree. Her interests outside of academics include dance (she is currently Vice President of the Dance Club at school), reading, and table tennis. She also believes in participating in student government and is now Senator of her Social Science class for the second straight year.

The ICP Experience Multiplier Effect:

High School for Environmental Studies Proposes Integration of NASA Research into School Curriculum

By Susane Colasanti, Umit Kenis, and Leila Woolley

SCHOOL PROFILE

The High School for Environmental Studies (HSES) was founded in 1992 with the goal of becoming a national model of urban environmental education. The school was designed to provide challenging academic courses and service opportunities to urban youth. The school is ethnically diverse and has a current enrollment of 1258 students of which 35% are Hispanic, 28% Black, 20% White, and 17% Asian. The school offers numerous extra-curricular activities for students to become involved in projects that promote living in harmony with natural and human-made environments in New York. Students can explore connections between concepts, facts, and skills learned in the classroom and their applications to the real world. They also gain a level of experience and support that they can utilize in subsequent internships or employment opportunities.

HSES is one of five new schools joining the ICP School Network, all of which are dedicated to the ICPís mission to provide opportunities for minority under-represented students to develop an interest in the sciences by entering the field. The HSES approach is to create an on-campus environment that will nurture this goal by enhancing our existing science program with a methodology for infusing ICP-inspired projects, consisting of sets of activity units enhanced by an after-school enrichment program.

Primarily, lessons, activities, and hands-on investigations inspired by NASA research will be integrated into the existing Regents Earth Science curriculum, as well as the new Meteorology/Weather and Climate course scope and sequence. These units of exploration, focusing on weather- and climate-related processes, will include in-depth examinations specifically focusing on urban climate change. The students will gain authentic scientific knowledge by assigning personal relevance to climate topics, developing meaning through critical thinking, and creating an intimate relationship with a dedication to life-long learning.

Additionally, we intend to implement an after-school enrichment program, whereby students will utilize the NASA Research Room as an extension of the class activities described above. Students in the Earth Science and Meteorology/Weather and Climate courses will be the main recruitment pools for the extra-curricular program. Our goal is to expose the maximum number of students to NASA-based research in order to further the interests of students in careers in science. Engaging in the ICP School Network with other institutions will provide a rich opportunity for technological enhancement, cooperative learning, and the exchange of ideas about science.

Progress to establish the program at our school has been slow, yet deliberate. As a public school, our funding is limited. We are facing difficulty in finding funds to purchase equipment such as computers, printers, an Internet connection, and a weather station. Numerous meetings with the administration have resulted in, as of October 15th, assurance that we will have their full support provided necessary funding is available. We

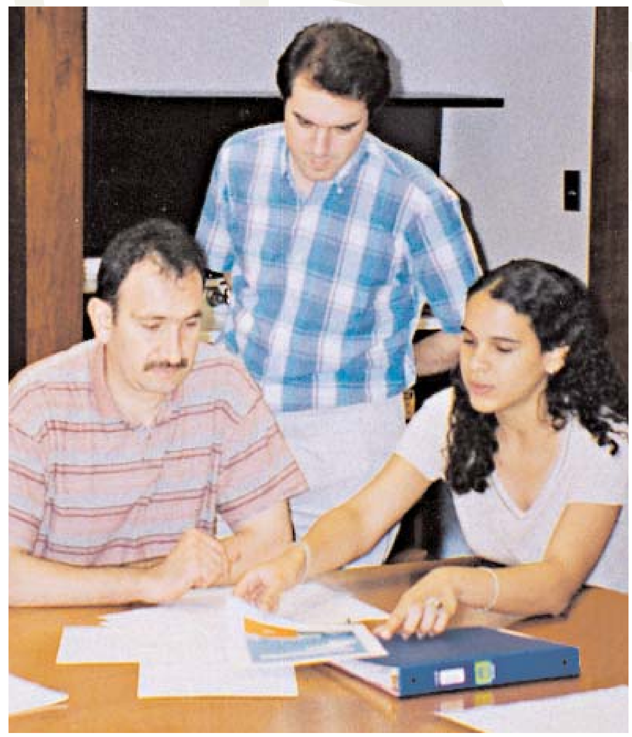
The challenge of bringing the ICP back to class is getting students the tools and confidence to find their way (in a problem) when pointed in the right direction.

— GISS Scientist

have been given a room and promised two computers in a few weeks, and an Internet connection in approximately eight weeks. The administration's support for our efforts to launch the ICP research program at HSES is much appreciated.

Long-term ICP school plans call for implementing a staff development initiative to expose more educators to our process of curriculum development, and involve more students in the program at other institutions. HSES educational philosophy strongly advocates involving students with a leading scientific institution, like NASA GISS, recognizing the motivating aspects of working with scientists and other individuals dedicated to understanding the evolving world of science. We believe that our collaboration with ICP will enhance hands-on opportunities for HSES students to learn science, surmounting traditional teaching pedagogies to inspire students' extended dedication to exploring science.

Participants in the ICP summer '98 program include Faculty members: Susane Colasanti, Umit Kenis, and Leila Woolley , and students: Rosa Andujar and Tariq Jones.



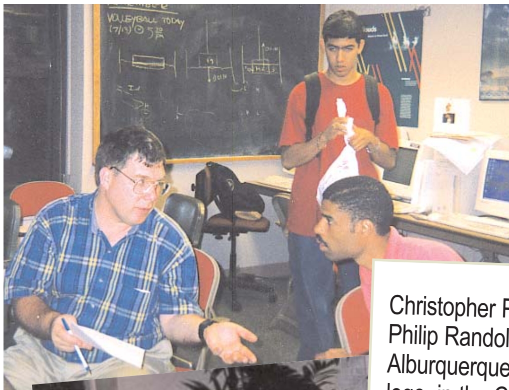
Umit Kenis (at left), teacher, and Rosa Andujar (right), student, both at High School for Environmental Studies, prepare for campus-based research with their GISS science advisor, Dr. Lionel Pandolfo (center).

Science research is a process. You have to constantly review your work, correct errors, look for new ways to solve a problem or better ways to understand the problem.

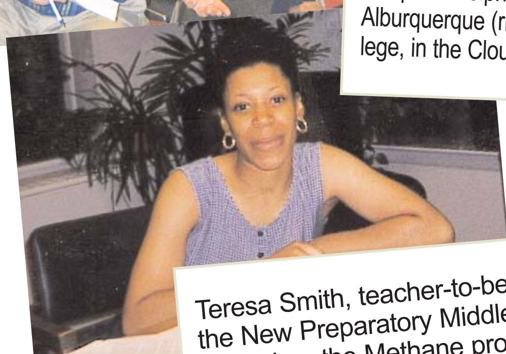
— ICP Faculty

OUTREACH

Highlights from the GISS Summer Institute



Christopher Petersen (at left), teacher at A. Philip Randolph High School, and Jose Alburquerque (right), student at City College, in the Clouds team's office.



Teresa Smith, teacher-to-be at the New Preparatory Middle School on the Methane project.

Ingemar Imbert and Michelle Guzman, from George Washington High School, during the Pollen field trip to the New York Botanical Garden.

Time off together: ICP summer '98 participants on a boat ride around Manhattan.

Climate Research: 48 students and educators contribute to climate research projects, with four new high schools and one new junior high participating. Veteran students and teachers assumed leadership roles in meeting the research and education goals of the program. GISS scientists felt this was our most productive summer for research!

- **Jim Hansen's Berenstain Bear Talk:** Encouraging participants that the way "NOT" to do science is by acting as professional debaters or lawyers who have pre-established positions. Instead, develop positions based in scientific evidence and objectivity.
- **Opening Day Talk:** "How Do Observations Become Datasets and How Do Datasets Become Information?" by Bill Rossow, NASA GISS Scientist.
- **Writing Workshop:** Series of workshops for students, teachers and scientists to write science abstracts and articles (modeled after the *New York Times Tuesday Science Times*) to inform the public about climate research. Designed to develop skills for "How to Write a Scientific Story", "Critiquing Science Articles For Scientists and the Public," and "Developing Criteria to Evaluate Science Writing".
- **Earth Climate Workshop:** Introduction to fundamental science concepts related to ICP research projects—climate variability, atmospheric pressure and modeling. Education activities are part of curriculum modules under development in the ICP Earth Climate Course for teachers and education students.
- **Faculty Working Group:** Organized to evaluate the current and potential contribution of climate research to science education. Engaged 16 educators to develop science benchmarks, assess ICP education modules, establish common themes, ideas and approaches in research, and identify frameworks (based on NYS Science Standards) for next generation of research/education activities.
- **Science & Society Seminars:** Lectures and discussions with outside experts to connect the ICP research projects to societal concerns. Also, to develop the ability to ask critical questions and reason about public issues in terms of our current scientific understanding.
  - **Speakers:**
  - Noel Brown, Former Director, United Nations Environment Programme
  - William Stevens, Chief Science Writer, *New York Times*
  - Laura Zeiher, author of *The Ecology of Architecture*
- **Educational Field Trips:** Pollen team field trip to the New York Botanical Gardens and Impacts team field trip on the Hudson River Sloop.
- **Sports and Recreation:** Cultural Heritage Pot-Luck Lunch, Volleyball, Basketball, and Soccer, Blues Cruise on the Hudson, IMAX Movie Night: Everest.

Summer '98 Research

Conducting research requires multiple talents. A team can maximize the talents of different people. A group is like piecing together a puzzle. When you put them together, they complete each other.

—ICP Student

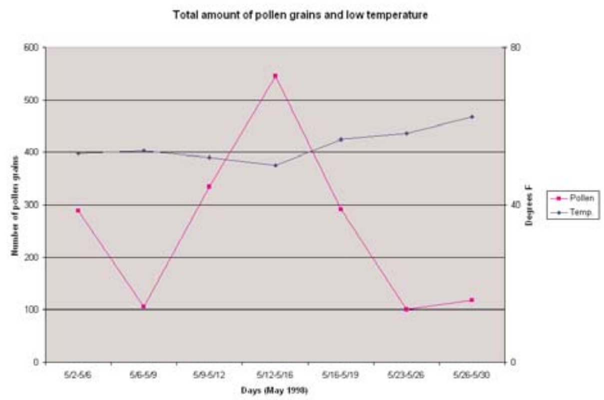
Pollen

Pollen Research Findings: excerpt from Ingemar Imbert's summer research article The Allergy Nightmare: A Palynologist's Dream

Local pollen collection methods approved for developing a pollen record, with minor changes recommended to increase resolution. Preliminary results show pollen production correlation with temperature and humidity.

While we all enjoy the sight of new plants and flowers in the spring and summer, a drawback for many people are the allergies provoked by the pollen. The research of the ICP pollen team began by examing the weather conditions which were directly related to pollen production in the New York City metropolitan area, for 1998. As the team continues its research in the next several years, annual variation in pollen production will be correlated to climate records. The ICP team's research may ultimately be able to aid farmers, by providing statistical correlations between weather conditions, and optimal pollination times. The results could be useful to public health officials studying correlations between asthma outbreaks, and air quality.

The most recent pollen signature, a day-by-day count of the pollen types found in the air, from the New York City area dates to 1954. Local vegetation has since changed drastically due to development. Would the 1998 vegetation still produce a pollen signature similar to that from 1954? Before answering that question, the ICP pollen team had to establish experimental protocols for long-term study. This was the first research summer. The team decided on the number of pollen types that needed to be identified, collected herbarium-quality samples for pollen microscope reference slides, and then experimented with different techniques for collecting the pollen. These protocols are easily adaptable to other school campuses. The pollen collection protocol established helps ensure that pollen signatures from future years, and even different locations, can be compared with each other.



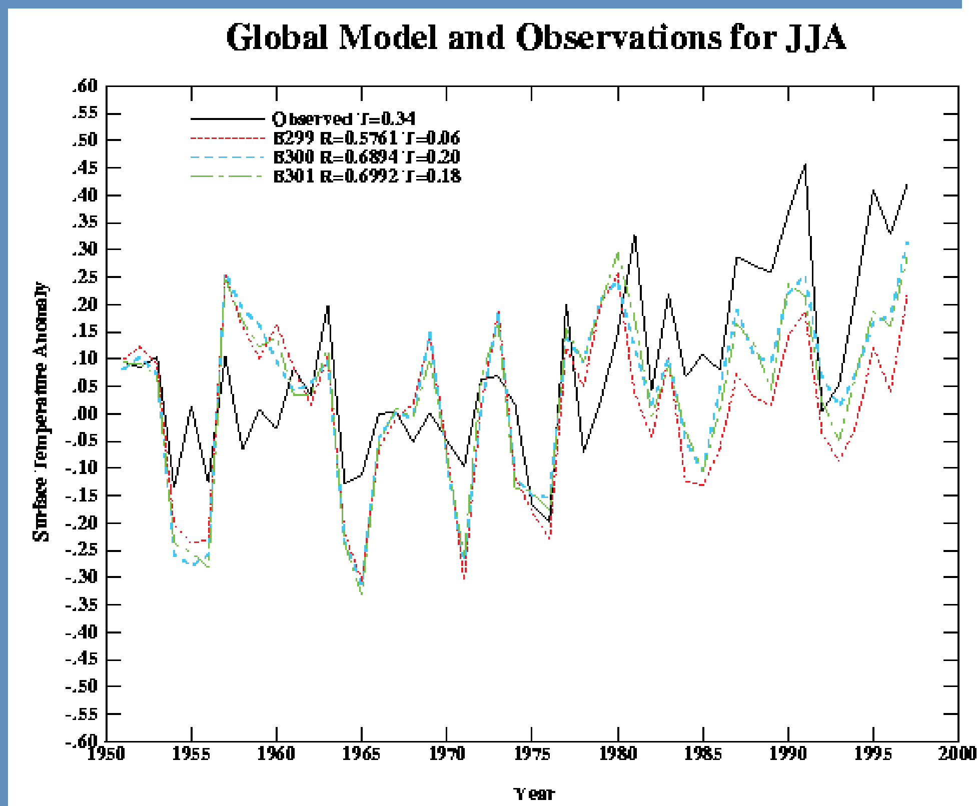
Total pollen in May are graphed against the lowest temperature averages.

Returning to the initial question, yes, periods of peak pollen counts for specific trees and herbs in 1998, were usually quite similar to the peak counts in 1954! Statistical correlations with weather conditions were made for May and July 1998 months the team had abundant pollen count data. The team found moderate correlations between the total amounts of pollen, and temperature and humidity. More interesting is the result that when low temperatures increased, total pollen decreased, and vice versa. When humidity rose, so too did the total amount of pollen collected. Future comparisons should lead to a better understanding of how local and regional weather conditions control pollen production. Other spin-offs from this research can be how climate and vegetation interact, whether changes in the pollen signature can be linked to land development, and if specific pollen types are correlated to health problems.

Summer '98 Research

Research is propelled by a question but directed by unforeseen results.
— ICP Faculty

Forcings and Chaos Model Research Findings: excerpt from Rosa Andujar and Sonjae Wallace's abstracts, Can Computer Models Simulate the Real World and Testing the GISS GCMs **Predictability?**



New GISS GCM exhibits a better climatology and improved predictability compared to the previous version.

General Circulation Models (GCMs) are the approximate mathematical representation of the earth's climate system which scientists use to understand climate variability and predictability. Scientists are constantly engaged in model development to add more detail that represents the atmosphere more accurately. Some of the improvements deal with better mathematical representations of key physical processes thought to influence climate, while other improvements consist of increasing the spatial and temporal resolution of the model. This research team assessed the ability of the GISS GCM (SI97) to reproduce atmospheric temperature at the earth's surface, in the troposphere, and in the stratosphere. Overall, comparisons between the new model and observations show a better representation of temperature in both the summer and winter seasons. In particular, there is a significant improvement in the model's North American winter, compared to the previous model, which overestimated the warmth of the winters. The temperature discrepancy between observation and the old model range from –3.6 degrees C to 14.1 degrees C while the discrepancies relative to the new model varied only from –3.6 degrees C to 2.2 degrees C. However, the new model still displays too cold temperatures in high northern latitudes in both seasons. In the tropical stratosphere, there is excellent correlation between the new model and observations. With regard to the question of predictability, time series of global average temperatures over the period 1951 to the present were studied for a number of successive forcings, starting with prescribed Sea Surface Temperatures, then adding observed greenhouse gases and finally, observed stratospheric aerosols. These time series are compared with the observational record, and the correlation is quite high, and improves significantly with the introduction of greenhouse gases, and changes only marginally with the addition of the stratospheric aerosols.

Contributor: Samuel R. Borenstein, York College

Summer 1998 Final Conference
Unfinished Chapters in the Climate Story

CONFERENCE HIGHLIGHTS: 170 STUDENTS, PARENTS, EDUCATORS, AND SCIENTISTS ATTEND

Opening Remarks: *Viewpoint on Research Education,*
Neville Parker, Principal Investigator, GISS/CUNY Cooperative Agreement, Director, Institute for Transportation Systems, City College of New York

Keynote Address: *Science as a Way of Thinking.*
Neil Tyson, Frederick P. Rose Director, Hayden Planetarium

More than 65 poster presentations inform the public about NASA GISS climate research and the ICP education spin-offs in science classrooms

Highlights from the summer '98 Faculty Working Group
Barbara Poseluzny, A. Philip Randolph High School, Lead Science Assistant Principal for Manhattan
Leila Woolley, High School for Environmental Studies

Roundtable Discussions: students, educators, and scientists
Research + Education = ICP: Is the Sum Greater than the Parts?

SSAI College Scholarship Awards presented to three ICP students

ICP Summer '98 Conference: from left to right — Joshua Wilder, Polytechnic University; Dr. Neville Parker, City College; Dr. James Hansen, NASA GISS; and Dr. Neil Tyson, Hayden Planetarium.

Katherine Chance (right), George Washington High School, presents the Pollen project's posters to GISS/Columbia University research scientists, Dr. Leonard Druyan (left), and Dr. Margaret Kneller (center).

Clouds research poster by ICP student researcher Jericco Tolentino (right) is scrutinized by Dr. James Hansen (center), and Dr. George Tselioudis (left), GISS/Columbia University.

Thema Graves (left) and Jasmine Pervis (right) from Career High School, Connecticut, present their summer research done during Southern Connecticut State University's campus-based ICP spin-off program.

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